STRATEGY FOR ENHANCEMENT OF THE EASTERN SNAKE RIVER PLAIN AQUIFER MODEL

Prepared by:
Eastern Snake Hydrologic Modeling Committee

(10/20/00)

THE EASTERN SNAKE HYDROLOGIC MODELING COMMITTEE (ESHMC) is composed of hydrologists and modelers from state and federal agencies, private industry and the University of Idaho. The group was formed in 1998 with the following mission:

Evaluate the status of hydrologic modeling on the Eastern Snake River Plain and tributary basins, define objectives for modeling efforts, assess data and technical needs, and provide technical support and peer review for the modeling process.

This report represents the committee's opinion on the procedures that should be adopted and funded to improve the capabilities and reliability of the Eastern Snake River Plain Aquifer (ESRPA) model.

STATEMENT OF NEED

The ESRPA model is being called upon increasingly to address planning and management issues including those of conjunctive management of surface and ground water. The strategy described in this document seeks to improve model reliability and quantitatively express the uncertainty associated with model predictions through the application of emerging technology and the acquisition of new hydrologic information.

OBJECTIVES

1) Establish a coordinated, inter-agency approach to improve the ground water flow modeling system of the ESRPA to address the demands of current and emerging water resource issues within a reasonable cost and timeframe. The coordination will pull together what may otherwise be piecemeal efforts of agencies into an organized and comprehensive program.
2) Enhance and refine the existing model to better represent the physical system, with an emphasis on the interactions of surface water and ground water.
3) Develop a framework (process/procedure) to quantify estimates of uncertainty in model parameters and predictions.
4) Establish a framework within which modeling work is implemented, coordinated and reviewed among experts in state and federal agencies and universities.

PROCEDURE

The ESRPA model enhancement program will be implemented through partnerships between the Idaho Department of Water Resources, Idaho Power Company, the University of Idaho, the U.S. Bureau of Reclamation, and the U.S. Geological Survey.

The strategy is composed of three main elements and associated tasks, as shown on the attached diagram, “Strategy”. Separate workplans are being developed for each of the three elements, detailing specific objectives, approaches, tasks, and deliverables. Investigations related to these three main elements are expected to proceed in parallel. All three contribute toward reducing the level of uncertainty and increasing the reliability of the ESRPA model.

The three strategy elements that proceed in parallel are identified as: A) numerical model refinement, B) development of data processing tools and C) advancement of the conceptual model. Within each element, major tasks are identified which proceed sequentially. The organization of parallel elements and sequential tasks is diagrammed on the attached diagram.

Some of the tasks identified in the figure and described below are interrelated, and consequently work on these tasks must be carefully coordinated. The coordination of activities will be accomplished through the Eastern Snake Hydrologic Modeling Committee (ESHMC), which will review workplans and reports, and provide feedback and guidance to individual investigators.

ELEMENT A. NUMERICAL MODEL REFINEMENT

The present ESRPA model calibration is based upon hydrologic conditions that are representative of a single year: 1980. Uncertainty increases when a model is used to represent hydrologic conditions moderately different from the conditions under which it was calibrated. Calibration using multi-year data sets will improve the confidence in the ESRPA model by calibration to a wider range of Snake River Plain hydrologic conditions.

TASK A1. Model RECALIBRATION USING MULTI-YEAR CONDITIONS

Model recalibration involves development of a multi-year data set, and estimation of aquifer properties using statistical methods, which minimize total model error. This task is intimately linked to the uncertainty analysis of Task A2, and the two will be jointly scoped in a work plan. It is expected that the multi-year recalibration data set will span a twenty-year period from 1980 to 2000. The present ESRPA model is calibrated to 1980 transient conditions. Calibration to a longer-term data set may improve the capability of the model to represent a wider range of hydrologic conditions and will improve confidence in the parameterization and conceptual validity of the model.

All available hydrologic data will be used to develop recharge and discharge data sets and provide calibration targets (ground-water levels and spring discharges) for the 1980-2000 period. The time-domain recalibration will be performed at six-month intervals. Hydrologic data which must be collected, analyzed and formulated for use by the ESRPA model include irrigated acres, ground water and surface water use, irrigation returns, canal seepage, stream gains, tributary basin underflow, irrigation diversions, crop distribution, and precipitation/climate information. Calibration targets will be developed from monthly or semi-annual measurements of ground-water levels and spring discharges. The ground-water levels will include data from a mass measurement of approximately 900 wells on the plain for the spring and fall of 2001.

The conceptual model will be evaluated and revised as might be warranted by the current understanding of the physical system. A parallel effort to collect data in support of conceptual model development (Element C) will be coordinated with this effort. The parallel development of a GIS-based data processing platform and data sets (Element B) will also be coordinated with Element A tasks, to ensure that the model calibration data can ultimately be incorporated into the data processing platform.

Funding

Source	Amount
IDWR/IPCO	$ 820,500
USGS	$ 150,000
Total	$ 970,500

Task A2. Non-Linear Parameter Estimation and Uncertainty Analysis

Non-linear parameter estimation involves the development of an objective function, which represents the discrepancy between model predictions of ground water levels and discharges and the calibration targets. Model calibration is achieved by minimizing the objective function through application of statistical methods. Application of parameter estimation methods, through the use of a commercially available tool such as PEST, also produces information on the sensitivity of the objective function to individual parameters. This information on parameter sensitivities is the key element for uncertainty analysis. Calibration target data and model parameters are weighted to reflect varying levels of uncertainty. This uncertainty can be propagated within the model and expressed through confidence bands placed on model predictions.

Parameter estimation and uncertainty analyses are used to identify areas of the plain where additional data is most important for improving model reliability. They also indicate the types of data which are most valuable (e.g. measurements of ground water levels, or spring discharges). Given the high cost associated with data collection, this is a vital step of the design process. Parameter estimation and uncertainty analysis will be used initially to improve the conceptual model and model calibration and finally in the uncertainty analysis.

Funding

Source	Amount
IDWR/IPCO	$ 110,000
USBR	$ 225,000
Total	$ 335,000

Task A3. Updating the ESRPA Model Base Study

The base study scenario is envisioned to be a baseline for long-term comparison of impacts resulting from changes in aquifer recharge and discharge. The base study model will represent average conditions over the 20-year calibration period, incremented in monthly time steps. It will be run to steady state conditions and then used to evaluate changes in aquifer stresses (recharge and discharge).

Funding

Source	Amount
IDWR/IPCO	$ 20,000

Task A4. Calculate River Response Functions

The updated model will be used to calculate river response functions, which indicate the effect of aquifer recharge or discharge on gains to the Henrys Fork and Snake rivers. These functions are an important part of developing strategies for conjunctive management of surface and ground water supplies.

Funding

Source	Amount
IDWR/IPCO	$ 50,000

Element B. Development of Data Processing Tools

Task B1. Adaptation of Recharge Program to a GIS-Based Data Management Platform

The majority of effort in construction of a regional ground water model is in collection and processing of hydrologic data, much of it spatial data. In order to make processing of hydrologic data more efficient, the data manipulation process associated with developing new model data sets will be adapted to take advantage of GIS-based data management software. By enabling graphical display of data, GIS will also reduce the potential for error in data processing, thereby enhancing model reliability. A work plan will be prepared that describes this specific task.

Funding

Source	Amount
IDWR/IPCO	$ 75,000

Task B2. Application of SEBAL to estimate ET.

Remote-sensing based algorithms for predicting evapotranspiration (ET) are just now becoming robust enough to facilitate widespread application. Using satellite information, SEBAL presents a means for relatively quick and widespread prediction of evapotranspiration over large areas and land types. Changes in crop types and land use over the 1980 to 2000 period and their impacts on ET fluxes will be determined. This information will be valuable for improving estimates of ground water recharge in both time and space and in assessing deep percolation fluxes from irrigation projects for the ESRPA.

Funding

Source	Amount
IDWR/IPCO	$ 75,000
(NASA/OTHER?)	$ 300,000
Total	$ 375,000

ELEMENT C. ADVANCEMENT OF THE CONCEPTUAL MODEL

Possibly the greatest potential for enhancement of the existing model is in addressing the lack of adequate understanding and representation of river and aquifer interaction. This is especially important for a model that is expected to be used more and more to address conjunctive management issues.

TASK C1. REFINING MODEL BOUNDARIES AND UNDERSTANDING OF SURFACE AND GROUND WATER INTERACTION

Model boundaries will be examined and consideration will be given to expanding the modeled area to include major tributaries. Additional data will be collected in this task to improve the river/aquifer conceptual model. New technologies will be employed that enable more efficient and accurate determination of river gains and losses. In areas along the Snake River, existing and new aquifer water level data will be compared with river stage data and estimates of river gains and losses. The comparison will be used to 1) evaluate the conceptual model of gains and losses, 2) estimate properties controlling gains and losses, and possibly 3) to refine the model representation of river reach/aquifer boundaries. The improved conceptual model and property estimates will be incorporated into the regional ground water flow model and will be useful for identifying limits on the magnitude and direction of interaction between surface and ground water for the surface water models that are used by the Department of Water Resources and the Bureau of Reclamation. Some work on this task has been initiated in the Thousand Springs area under funding by the U.S. Environmental Protection Agency and on the Snake River between Shelley and King Hill through a cooperative agreement between the IDWR and the USGS. Further work is required for the Upper Snake and the American Falls area.

Although it would be ideal to have all conceptual model development done prior to Tasks A1 through A3, this sequential arrangement is not practical. Efforts to improve our understanding and representation of the system must continuously progress and be incorporated into models at convenient opportunities.

Funding

Source	Amount
IDWR/IPCO	$250,000

TASK C2. COLLECTION OF IRRIGATION SEEPAGE/RETURN DATA

At the current time, little is understood about the rate of seepage from irrigation canals or about the rate of irrigation return flows. This task would entail a combination of field work and literature review to improve the current understanding of these two areas. The fieldwork would involve measuring seepage losses and irrigation returns from several irrigation canals ranging from large to small. The literature review would involve researching publications on this topic, to see how these two rates are estimated in other basins. These measured and published numbers would then be applied to canals throughout the Snake River plain.

Funding

Source	Amount
IDWR/IPCO	$ 150,000

TASK C3. INVESTIGATE SATURATED ZONE DEEP PERCOLATION TRAVEL TIME

This task is comprised of a research task to determine how much of pumped ground water is consumptively used, how much returns to the aquifer and what the delays of the returns are. This task is envisioned as a literature research effort. Field investigations are beyond the proposed scope.

Funding

Source	Amount
IDWR/IPCO	$ 50,000

TASK C4. DETERMINATION OF GROUND WATER AND SURFACE WATER IRRIGATED AREAS

This task entails the estimation of current estimates of ground and surface water irrigated acres. For the long-term calibration, it is assumed that the total number of irrigated acres in the Snake River plain would be determined from satellite imagery. The assignment of these acres to ground water irrigated acres and surface water irrigated acres is more complex. This task would involve analysis of adjudication data base records, satellite imagery and possibly field verification to delineate the difference between surface and ground water irrigated acres. This would include updating the irrigated lands database to include 2000 data.

Funding

Source	Amount
IDWR/IPCO	$ 75,000

RESULTS

The results of the three parallel elements of work will come together to produce a more representative ground water flow model with improved data processing capabilities, and improved understanding of model uncertainty and predictive reliability.

PARTNERSHIPS and SCHEDULE

The proposed project elements will be accomplished through a partnership of the Idaho Department of Water Resources, Idaho Power Company, the U.S. Bureau of Reclamation, the University of Idaho, and the U.S. Geological Survey. This strategy provides a means of drawing together into a coordinated approach what would otherwise be independent research projects. Funding is being sought to accomplish the ESRPA model enhancement as shown in the table below. The duration of the project is expected to be three years.

ESRPA MODEL ENHANCEMENT STUDY COSTS (1000's of Dollars)					
Task	2002	2003	2004	Total	Source
A1	298.5	288.5	233.5	820.5	State/IPCO
	50	50	50	150	USGS
A2	75	75	75	225	USBR
		55	55	110	State/IPCO
A3			20	20	State/IPCO
A4			50	50	State/IPCO
B1	25	25	25	75	USBR
B2	25	25	25	75	State/IPCO
	100	100	100	300	Other(?)
C1	80	80	90	250	State/IPCO
C2	75	75		150	State/IPCO
C3			50	50	State/IPCO
C4	55	10	10	75	State/IPCO
Total	783.5	783.5	783.5	2350.5	
State	408.5	408.5	408.5	1225.5	
IPCO	125	125	125	375	
USBR	100	100	100	300	
USGS	50	50	50	150	
Other(?)	100	100	100	300	
Task A1	Model recalibration using 1980-2000 conditions				
Task A2	Uncertainty analysis				
Task A3	Development of a 2000 conditions steady state base study				
Task A4	Calculate river response functions				
Task B1	Adaptation of GIS-based recharge program for data management				
Task B2	Application of SEBAL to estimate evapotranspiration				
Task C1	Refine model boundaries and hydraulically connect river reaches				
Task C2	Collect data to define canal seepage and return flow				
Task C3	Investigate unsaturated zone deep percolation travel time				
Task C4	Determine ground water/surface water source for irrigated areas				

EASTERN SNAKE HYDROLOGIC MODELING COMMITTEE
(11/22/99)

Ron Abramovich
National Resource Conservation Service

Rick Allen
University of Idaho
Kimberly Research and Extension Cntr

Hal Anderson
Idaho Dept. of Water Resources

Jon Bowling
Idaho Power Company

Tim Brewer
Idaho Power Company

Paul Castelin
Idaho Dept. of Water Resources

Donna Cosgrove
UI-Idaho Falls

Gary Johnson
IWRRI
UI/Idaho Falls Center for Higher Education

Pat Lambert
U.S. Geological Survey - WRD

Roger Larson
U.S. Bureau of Reclamation

John Lindgren
Idaho Dept. of Water Resources

Dick Lutz
Idaho Dept. of Water Resources

Christian Petrich
Idaho Water Resources Research Institute

Clarence Robison
Kimberly Research and Extension Center

Joe Spinazola
U.S. Bureau of Reclamation

Leslie Stillwater
U.S. Bureau of Reclamation

Robert D. Schmidt
U.S. Bureau of Reclamation

Bob Sutter
Idaho Dept. of Water Resources

Scott Urban
Idaho Department of Water Resource

Strategy

Parallel Elements

Task A

Numerical Model Refinement

- **Task A1** – Model recalibration using multi-year conditions
- **Task A2** – Non linear parameter estimation and uncertainty analysis
- **Task A3** – Updating the ESRPAM base study model
- **Task A4** – Calculate river response functions

Task B

Development of Data Processing Tools

- **Task B1** – Adaptation of recharge program to GIS-based data management platform
- **Task B2** – Application of SEBAL to estimate ET

Task C

Advancement of Conceptual Model

- **Task C1** – Refining model boundaries and understanding of surface and ground-water interaction
- **Task C2** – Collection of Irrigation seepage/return Data
- **Task C3** – Investigate saturated zone deep percolation travel time
- **Task C4** – Determination of ground-water and surface water irrigated areas

PRODUCTS

More representative model.

Quantitative estimates of uncertainty.

More usable model input device.

Improved understanding of data deficiencies.